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ANALYSIS OF TRACER GAS DATA FROM A STUDY OF AIRFLOW MOVEMENTS THROUGH A LEACHING STOPE IN A URANIUM MINE

A.W. Stokes and W.G. Klinowski
Cape Breton Coal Research Laboratory

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ANALYSIS OF TRACER GAS DATA FROM A STUDY OF AIRFLOW
MOVEMENTS THROUGH A LEACHING STOPE IN A URANIUM MINE

by

A.W. Stokes* and W.G. Klinowski**

ABSTRACT

The ventilation research group from CANMET's Elliot Lake Mining Research Laboratory undertook a tracer gas study to determine the airflow patterns through a stope undergoing leaching in one of Dennison's local uranium mines. The Cape Breton Coal Research Laboratory was asked for their assistance in analysing the raw data from this study using their extensive suite of computer programs which have been developed for this purpose. This report gives the results of the analysis and draws some conclusions about the airflow patterns in the stope and the efficiency of the system used to ventilate leaching stopes.

*Research Scientist and **Project Engineer, Cape Breton Coal Research Laboratory, CRL, CANMET, Energy, Mines and Resources Canada, Sydney.

ANALYSE DES DONNÉES DE GAZ TRACEURS DANS UNE MINE D'URANIUM À PARTIR
D'UNE ÉTUDE SUR LES MOUVEMENTS DES COURANTS D'AIR CIRCULANT
DANS UNE GALERIE SOUMISE AU LESSIVAGE

PAR

A.W. Stokes* et W.G. Klinowski**

RÉSUMÉ

Le groupe de recherche sur la ventilation du Laboratoire de recherche minière d'Elliot Lake a entrepris une étude pour déterminer le mode de circulation des courants d'air à travers une galerie soumise au lessivage de la mine d'uranium de Dennison. Le Laboratoire sur le charbon du Cap-Breton s'est vu demandé son assistance pour analyser les données brutes provenant de cette étude, en utilisant leur vaste gamme de programmes informatiques qui ont été développés dans ce but. Le présent rapport livre les résultats de cette analyse et tire quelques conclusions au sujet du mode de circulation des courants d'air dans une galerie et de l'efficacité du système servant à ventiler les galeries soumises au lessivage.

*Chercheur scientifique et **Ingénieur de projet, Laboratoire de recherche du Cap-Breton, LRC, CANMET, Énergie, Mines et Ressources Canada, Sydney.



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INTRODUCTION

The ventilation research group from CANMET's Elliot Lake Mining Research Laboratory (ELMRL) were invited to define the airflows through a leaching stope in one of Dennison's local uranium mines. This investigation was conducted during the summer of 1986 using ELMRL's then recently acquired tracer gas capability.

The stope under investigation was one of two in parallel and consisted of a worked out open stope which had been sealed on the intake side. Compressed air (for leaching) was fed into both stopes via pipes which ran almost their entire lengths. The pipes were perforated to allow the oxygen rich air to reach the broken rock in all parts of the stopes. The aim of the investigation was to determine the distribution of air into the stope from these pipes. This was done using a continuous release (at a steady flow rate) of the tracer gas sulphur hexafluoride into the compressed air lines then monitoring the resultant concentration build up in the exhaust air from the test stope. After steady state was achieved the tracer gas injection was stopped and the resultant decay in the exhaust air concentrations was also measured.

The data has been supplied to the Cape Breton Coal Research Laboratory (CBCRL) for basic analysis using specialty computer software techniques developed in house. This report documents the results of this preliminary analysis together with some conclusions and suggests some recommendations for future work.

RAW DATA SUPPLIED

Table 1 lists the raw data which was supplied to CBCRL. This data was given as the elapsed time since the start of the continuous injection and the percentage of the steady state concentration measured in the sample.

The tracer gas flow was 18.43 ml/min of 0.95 percent SF_6 and the steady state concentration reached in the exhaust air was 112.8 ppb. The gas supply was turned off 130 hours after the start of the injection.

Figure 1 shows this information graphically, the data points are represented by the asterixs.

Table 1 - Raw data from study

Elapsed Time (hrs)	Percentage of Steady State Concentration (%)	Elapsed Time (hrs)	Percentage of Steady State Concentration (%)	Elapsed Time (hrs)	Percentage of Steady State Concentration (%)
0.00	0.00	120.50	98.89	168.00	35.85
3.00	0.95	121.50	97.51	170.00	32.32
4.50	4.21	122.00	96.66	171.00	33.53
23.00	46.29	123.50	100.00	172.00	30.88
24.00	51.68	125.00	100.00	172.50	32.46
25.00	55.66	130.50	97.98	192.00	17.26
26.00	58.80	131.50	96.68	193.00	16.56
27.00	62.96	132.50	94.77	193.50	15.00
28.00	67.08	133.50	93.40	194.00	16.16
34.75	82.15	134.50	91.24	195.00	16.40
35.75	84.75	135.50	90.66	196.00	12.93
37.75	89.78	143.00	75.00	197.00	14.34
38.75	88.41	144.00	69.20	202.50	11.16
39.75	90.70	145.00	71.80	204.50	11.84
48.50	86.46	146.00	70.14	205.50	9.96
49.50	93.13	147.00	68.01	207.50	7.99
50.50	91.56	147.50	67.84	215.00	7.68
52.00	94.48	148.00	66.15	217.00	6.55
52.50	95.17	149.00	63.38	218.00	6.87
59.00	96.11	155.50	54.79	219.00	5.11
60.00	96.27	158.50	49.51	219.50	6.27
61.00	97.57	159.50	49.60	220.50	5.44
63.00	98.38	167.00	39.03	288.25	0.50
64.00	98.75				

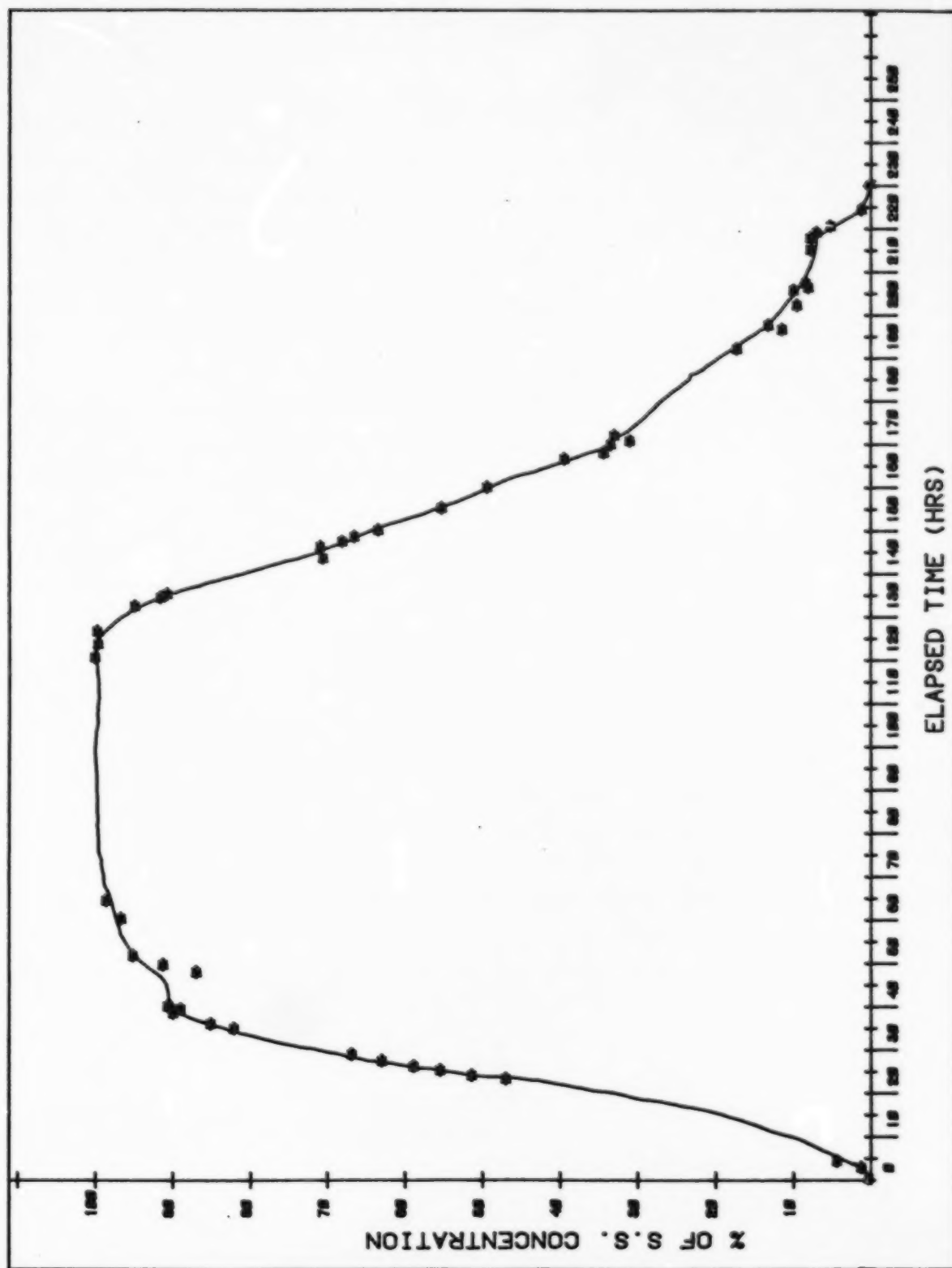


Figure 1 - Continuous injection profile

DATA ANALYSIS

CONVERSION TO PULSE INJECTION CURVES

Figure 1 shows the computer drawn version of the data points and the line which was used as the concentration/time profile. Using software described elsewhere (1) a TEKTRONIX 4052 computer and NEWMONICS digitizing tablet were used to digitise the concentration/time curve. This profile was then differentiated to obtain the equivalent profiles that would have been obtained from a 'pulse injection' of tracer gas. Two of these 'pulse injection' profiles were generated, one using the concentration build up section of the curve and the other using the decay part. These are shown in Figures 2 and 3 respectively. These curves are easier to interpret than the 'continuous injection' curve and their salient features are described in the discussion.

STOPE AIRFLOW

The airflow through the stope can be calculated using the following relationship:

$$Q = \frac{\dot{v}}{c} \quad \text{Eq 1}$$

where, Q is the stope airflow (m^3/s),

$\dot{v}$ is the flow of SF_6 (m^3/s),

and c is the steady state concentration of SF_6

measured in the exhaust airstream from the stope.

The volume of pure SF_6 was:

$$\begin{aligned} \dot{v} &= \frac{18.43}{60} \times \frac{0.95}{100} \\ &= 0.00292 \text{ ml/s} \\ &= 2.92 \times 10^{-9} \text{ m}^3/\text{s} \end{aligned}$$

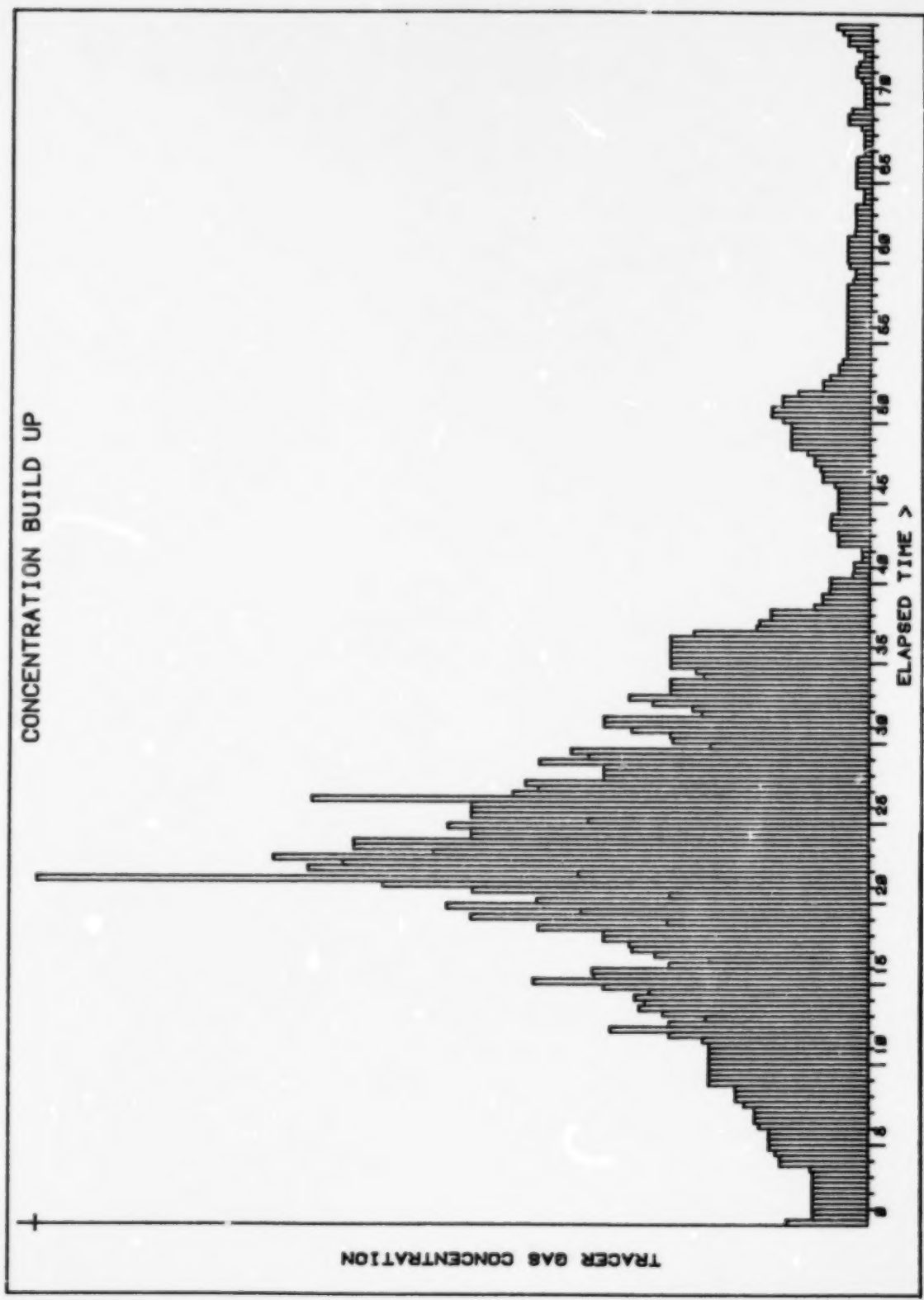


Figure 2 - 'Pulse injection' profile from concentration build up

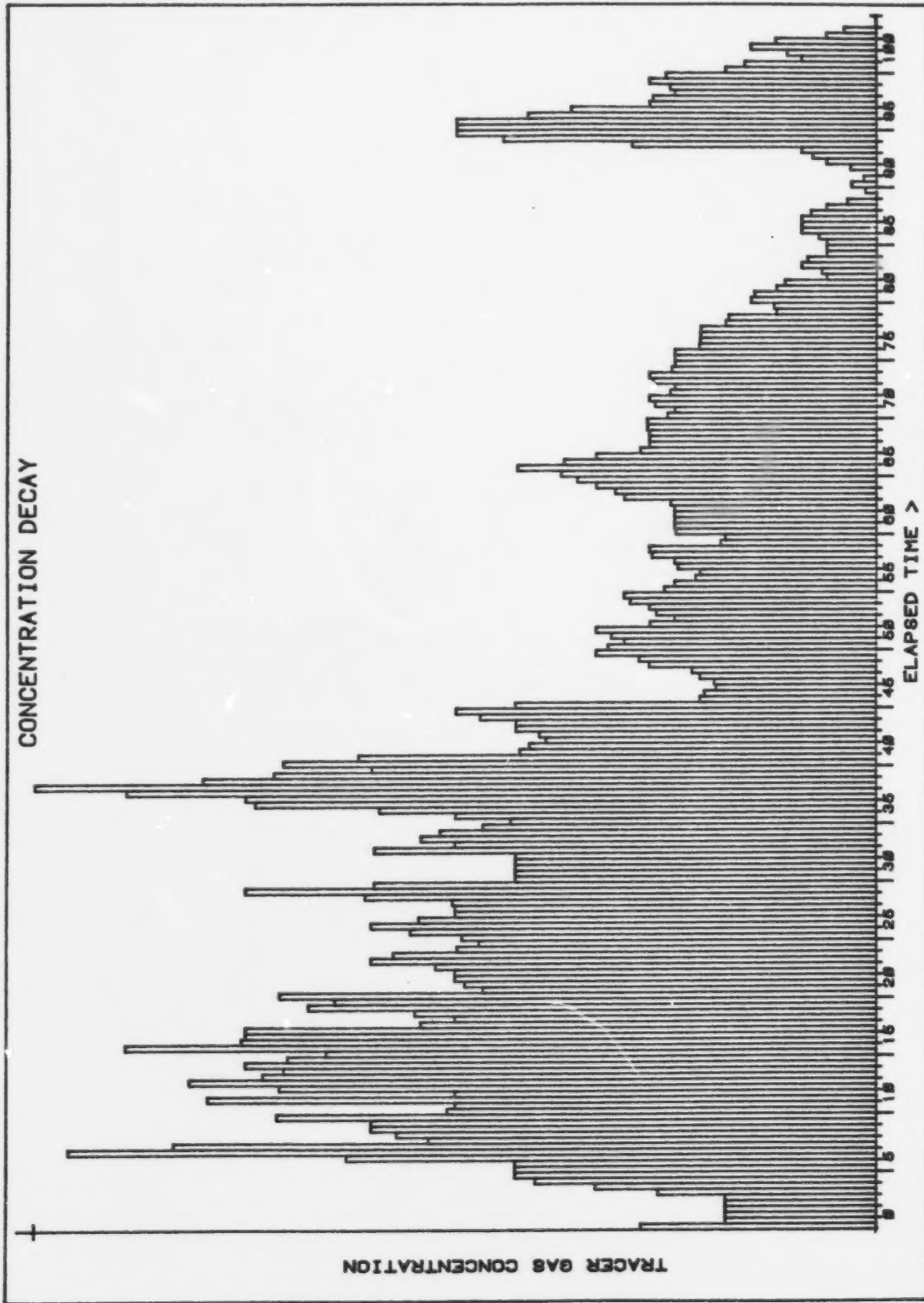


Figure 3 - 'Pulse injection' profile from concentration decay

Therefore the airflow through the compressed air lines was:

$$\begin{aligned} Q &= \frac{2.92 \times 10^{-9}}{112.8 \times 10^{-9}} \\ &= 0.02588 \text{ m}^3/\text{s} \\ &= 55 \text{ cfm} \end{aligned}$$

AVERAGE RESIDENCE TIME

The average residence time of the air in the compressed air lines and stope may be found from the t_{50} times (2). These are obtained from the build up and decay sections of the continuous injection profile and are the time from the start of the injection to reach 50 percent of the steady state concentration and the time from the turning off of the gas supply until the exhaust concentration fell to 50 percent of the steady state concentration. These times were 23 and 27 hours respectively.

TRAVEL TIME THROUGH COMPRESSED AIR PIPES

There was $0.026 \text{ m}^3/\text{s}$ of air being fed into the compressed air lines which run through the stopes. This volume flow was fed into six $\frac{1}{4}$ -inch diameter pipes, three in each of the two parallel stopes. Assuming that there was an even leakage of air from the entire length of these pipes then the average flow in them would be approximately $0.013 \text{ m}^3/\text{s}$. This equates to an average velocity in the compressed air lines of:

$$\frac{\text{Average Volume Flow Rate}}{\text{Total Pipe Cross-Sectional Area}} = \frac{0.013}{6 \times \pi \times (0.635 \times 10^{-2})^2} = 17.1 \text{ m/s}$$

This shows that the travel time inside the compressed air lines was negligible compared to that through the stope itself. Therefore for the purpose of analysis it may be assumed that tracer gas is introduced to all points within the stope simultaneously.

DISCUSSION OF DATA AND ANALYSIS

The raw data supplied for analysis was incomplete. A number of samples taken shortly after the start of the injection were lost. This

leaves the early part of the profile ill defined and some of it had to be sketched in with a 'best guess' line. This has a significant impact on the curve in Figure 2 since it is used in the differentiation. Therefore the curve generated from the decay from the steady state concentration is probably more representative of what a pulse injection would produce and for the purpose of interpretation this was used to infer the stope flow regimes.

Figure 3 shows the differentiation of the decay as a histogram. The real-time concentration profile of a pulse injection would follow the peaks of the histograms. There is no single significant peak that dominates the profile, rather there is rapid rise in concentration followed by a slow decay with a number of smaller peaks superimposed onto it. This indicates that the air was released along virtually the entire length of the pipes in the stope. There is however a single noticeable peak which reports to the stope outlet after the main body of gas. A similar feature is also noticeable in Figure 2. This peak shows that a substantial volume of air was released from the compressed air lines somewhere near to the stope inlet through a single point and after which little or no air was released for a significant distance. If this were not so, the peak would have become merged with the main body of gas (as are the other minor peaks). The size of the peak (compared to the area under the rest of the curve) gives an indication of the volume of air released at this point. It was certainly less than 10 percent of the total air volume released from the pipes.

Due to the nature of the release of the gas into the stope it is impossible to calculate for certain whether all parts of the stope are being supplied with oxygen rich air from the compressed air line. The best that can be done is to look at the transit time through the stope of the volume of air released from the pipe near the stope inlet. Assuming that the air was released roughly evenly along the remaining length of the stope then the average flow rate would have been half that at the stope inlet; i.e. $0.008 \text{ m}^3/\text{s}$ (approximately 60% of total was released into the stope under investigation). Multiplying this value by the transit time for the last peak gives a value for the stope volume of 2667 m^3 . If all the areas of the collapsed stope were ventilated and the assumptions about linear release of air from the pipeline is correct, then this calculated stope volume should be close to the actual. A value larger than the actual indicates that a greater proportion of the air was released nearer to the stope outlet or that not all

points were being ventilated. Conversely, a smaller value indicates that a larger proportion was released closer to the inlet.

CONCLUSIONS AND RECOMMENDATIONS

Although the data from this study was sketchy, some conclusion can be made. Firstly, the average residence time of air from the compressed air line in the stope was between 23 and 27 hours. Secondly, the total airflow through the compressed air lines into both stopes was $0.026 \text{ m}^3/\text{s}$. Thirdly, analysis of the decay section of the continuous injection profile indicates that air was released from a number of points along the compressed air lines in the investigation stope. These would appear to give an equitable distribution of air to most parts of the stope.

Due to the loss of data from the initial part of the injection these conclusions are based on only one trace. A higher degree of confidence would have been obtained if two identical traces from the build up and decay sections had been obtained. For future work of this type a better quality of information would be obtained from pulse injections of tracer gas into the stope near to the stope inlet. This would require an injection route independent of the compressed air lines. Such injections would give precise stope volumes, residence times and a better definition of the air as it was released from the compressed air lines.

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